# GENERAL INFORMATION FOR ILLINOIS NUT GROWERS

A. S. Colby[1]

The following brief comments may be helpful in answering some of the inquiries of those interested in nut growing in this state.

While certain nut species well adapted to northern United States are among the most palatable nut fruits on any market, commercial nut production in the north is not as important as in the west and south. In certain localities of southeastern and southwestern Illinois, however, the crop from the native pecan groves is often of important cash value.

One of the greatest opportunities for profit and pleasure in northern nut growing at present may be found in planting nut trees about the home, especially on the farm. Suitable kinds and varieties may be planted profitably on fertile but otherwise unused spots around buildings (where they may help to enframe the house and provide shade), along fences and ditches, on steep hillsides and in other so-called waste spaces. Seedlings already growing may often quickly be made more profitable by top-working them with scions of superior varieties of the same or closely related species. The necessity for a close relationship between stocks and scions is especially important with the chestnut.

## Nut Variety Recommendations for Home and Commercial Planting

Chestnut--[2]
Filbert--(European) Barcelona, Bolwyller, Daviana, Du Chilly, Italian Red; (American) Rush, Winkler
Heart Nut--Bates, Faust, Fodermaier, Stranger
Hican--(Shellbark-Pecan Hybrids) Des Moines, Gerardi
Shagbark Hickory--Glover, Kirtland, Romig, Swaim
Other Hickory Hybrids--Fairbanks (Shagbark X Bitternut), Pleas (Pecan X Mockernut)
Pecan--Busseron, Greenriver, Indiana, Kentucky, Major, Niblack, Posey (These varieties are more satisfactory in southern than in central Illinois and are not recommended for northern Illinois)
Walnut--Allen, Grundy, Ohio, Rohwer, Stabler, Stambaugh, Thomas, Ten Eyck

## Some Factors Which Influence Nut Production

Until more is known about the pollinating habits of nut varieties in general, each planting should include a few trees of several varieties of each of the species which is chosen. Cross-pollination is thus rendered more probable, and better nut crops will result.

---

1/ Professor of Pomology, Department of Horticulture.

2/ Chestnut blight is now generally prevalent in Illinois. Trees of highly desirable varieties, including Boone and Fuller, formerly profitable in orchard plantings, are dying out as a result of the disease. New plantings are likely to become infected and the trees killed within a very few years. Some of the Chinese and Japanese chestnuts are strongly resistant to blight and are now being planted conservatively with reasonable prospects of a favorable outcome. (Note C. A. Reed's pamphlet on chestnut planting under References on page 4.)

## GENERAL DESCRIPTION FOR ILLINOIS VIT CONTEST

L. M. Gallup[1]

The following brief comments may be helpful in answering some of the questions of those interested in new growing in this state.

Ohio varieties not specially well adapted to northern Illinois are some the most valuable nut trees on any market, commercial nut production in the north is not as important as in the west and south. In certain localities of southeastern and southwestern Illinois, however, the step from the native woods or tree is often of important cash value.

One of the greatest opportunities for profit and pleasure in northern nut growing at present may be found in planting nut trees along the lanes, especially on the farm. Suitable kinds and varieties may be planted profitably on farms but otherwise unused spots around buildings (where they may help to enhance the home and provide shade), along fences and ditches, on steep hillsides and in other so-called waste spaces. Feeding stock already growing may often quickly be made more profitable by top-working them with scions of superior varieties of the more or less closely related species. The necessity for a close relationship between stock and scions is especially important with the Hickory.

### The Varieties Recommended for Home and Commercial Planting

(Section--2)

Hybrids--(European) Paradox, Polyander, Davison, Ne Plus Ultra.
Native Nut: (American) Bush, Wickham
Hazel Nut--Rush, Pearl, Reformation, Giromagny
Chestnut--(Japanese-Chinese Hybrids) Lee Mammoth, Overall
Shellbark Hickory--Glover, Kentland, Stella, Weiss
(Shagbark Hybrids--Bixby and (Shagbark X Bitternut),
Illinois (Pecan X Mockernut)
Pecan--Busseron, Greenriver, Indiana, Mantura, Major,
Walnut, Stony (These varieties are more suitable
Butternut in southern than in northern Illinois and are
not recommended for northern Illinois)
Butt--Allen, Orange, Ohio, Barnes, Stabler,
Kleinwagen, Thomas, Ten Eyck

### Some Factors which Influence Nut Production

Until more is known about the pollinating habits of nut varieties in general, such planting should include a few trees of several varieties of each of the species which is common. Cross-pollination is thus rendered more probable, and better nut crops will result.

---

1/ Director of Research, Experiment of Horticulture.

2/ Varieties listed in the accompanying prevalent in Illinois. Items of hardy varieties, including Stone and Italian, Chestnut, particularly in northern plantings, are coming out as a result of the blizzard. New plantings are likely to prove in-[illegible] and the trees killed within a very few years. Some of the Chinese and [illegible] varieties are strongly resistant to blight and are now being planted [illegible] with reasonable prospects of a favorable outcome. (See N. [illegible] possibility on alternate planting under Nut Growing on page 6.)

The age at which nut trees come into bearing varies, depending upon the kind, the variety, the soil, and cultural care. Very young trees often set a few nuts, some or all of which drop before maturity. When grown in good soil, and otherwise well cared for, chestnuts and black walnuts sometimes bear a few nuts two or three years after planting; hickories and pecans may need twice that time or even more. However, most kinds require seven to fifteen years to attain sufficient size to bear important money crops. When well-established trees are top-worked with good varieties and are given good care, earlier crops of reasonable size may be expected than when young trees are set.

If the nuts fail to mature and to fill out properly, resulting in either undeveloped or shrunken kernels, the condition is likely to be due to one of the following causes: ineffective pollination, too short a growing season, too little or too much moisture at critical periods, infertility of soil, or premature defoliation by insects, diseases, or other natural causes.

Rapid temperature changes, especially sudden drops to several degrees below normal accompanied by high winds, often kill filbert catkins in winter or spring. The new shoots of black walnut, hickory, and pecan are also subject to damage by late spring frosts, especially in low spots which form frost pockets.

Weather conditions in Illinois are normally unfavorable for growing and fruiting either the Persian (English) walnut or the southern pecan. Many varieties of these nuts advertised as hardy and very promising have been planted in this section with disappointing results. A variety of Persian walnuts hardy in the Carpathian Mountains of northern Europe has been introduced by the Reverend Paul C. Crath, of Toronto, Canada, and is now available for trial. A descriptive pamphlet may be obtained from S. H. Graham, Bostwick Road, Ithaca, New York, who has a supply of the trees for sale.

## Suggested Sources of Nut Tree Nursery Stock

Benton & Smith, Wassaic, New York
Duis Nut Nursery, Shattuc, Illinois
Wm. Dependahl, Delhi, Illinois
Jos. Gerardi, O'Fallon, Illinois
Hazel Hills Nursery Co., River Falls, Wisconsin
Indiana Nut Nursery, Rockport, Indiana
J. F. Jones Nurseries, P.O. Box 356, Lancaster, Pennsylvania
Nut Tree Nurseries, Downingtown, Pennsylvania
E. A. Riehl Farm, Godfrey, Illinois
Snyder Brothers, Inc., Center Point, Iowa
H. F. Stoke, 1420 Watts Avenue, N. W., Roanoke, Virginia
Sunny Ridge Nursery, Swarthmore, Pennsylvania
Whitford Nursery, Farina, Illinois

These names are representative of firms specializing in nut tree propagation and featuring the best named varieties. Many nurseries handling a general line sell only seedling trees (not named varieties). Most seedling trees are unsatisfactory if early and productive bearing of good nuts is desired. In such cases prospective planters should insist upon varieties by name. Budded or grafted trees are more expensive than most other fruit trees because of greater expense in propagating, growing, and digging, but they will usually remain longer in productive

bearing. Also, fewer trees are usually needed to fill the space chosen for their planting, because most kinds reach a large size at maturity.

## Planting Distances for Nut Trees

Planting distances for nut trees vary, depending upon the kind and variety, the soil, and sometimes the amount of space available. It is unwise to crowd the trees, since they reach maximum production only when allowed sufficient area for root and top growth. Black walnuts in good soils take full advantage of 60-foot planting distances. The new Carpathian walnuts promise to be large trees and require 40 to 50 feet as a minimum planting space. Native hickories and pecans grow nearly 100 feet tall when given sufficient feeding area, and northern named varieties should be planted not closer than 50 feet apart. In orchard planting, Chinese and Japanese chestnuts should be allowed from 35 to 40 feet each way. Heart nuts and filberts are relatively small trees at maturity and may be set about 25 feet apart.

## Early Care of Nut Trees

Nut trees should be carefully planted and well cared for. At planting time, it is usually advisable to cut back the tree somewhat, unless the nurseryman has already done so. Do not crowd the root system into a small hole. Set the tree at least as deep as it stood in the nursery. Firm the soil about the roots as the hole is being filled. In windy locations the tree should be staked until it has become established. Mixing dampened peat moss with especially heavy or light soil will greatly improve its physical condition, particularly with respect to its moisture-retaining capacity, and will give the young tree a better start. Mulching with peat moss, straw, or similar material is helpful during dry weather, but the mulching material should be removed in the late fall. The ground about the tree should not be packed hard by stock or other means.

Watering may be necessary during the first and second growing seasons, and the ground should be soaked well at intervals during the hot weather. The formation of a shallow basin at the base of the tree facilitates artificial watering and retains rainfall.

An arsenate of lead spray in early summer controls walnut caterpillars. Protection against rabbit and mouse injury should be provided during the fall and winter months. Wrapping the newly set tree with paper, or shading the trunk, will help to prevent sunscald and damage from borers the first year or two after planting.

A minimum of pruning is necessary the first few years and should be confined to the removal of crossing and crowding branches, especially those which arise close to the ground. Pruning wounds should always be covered with a protective coating.

## References to Literature on Nut Culture

Books: The Nut Culturist--A. S. Fuller
Nut Growing--Dr. Robert T. Morris
Tree Crops, A Permanent Agriculture--J. Russel Smith
Standard Encyclopedia of Horticulture--L. H. Bailey
Hortus--L. H. Bailey

The last two books on the foregoing list include, under appropriate headings, basic information on nut culture.

U. S. Department of Agriculture Publications:

Farmers' Bulletins
700[1] - Pecan Culture with Special Reference to Propagation and Varieties
843[1] - Important Pecan Insects and Their Control
995[1] - Preventing Wood Rot in Pecan Trees
1392 - Black Walnut for Timber and Nuts
1501 - Nut-Tree Propagation

Mimeographed Pamphlet
Chestnut Planting Again Attracts Interest (by C. A. Reed)

Miscellaneous Publication
302 - Nuts and Ways to Use Them

Leaflets
71 - Fertilizers for Pecan Soils
84 - Planting Black Walnut

The 1925 Yearbook of the U. S. Department of Agriculture includes considerable information on nut culture and a discussion on the nutritive value of fruits, vegetables and nuts. The 1937 Yearbook of the U.S.D.A. includes a comprehensive chapter on nut breeding which is available from the Superintendent of Documents, Government Printing Office, Washington, D. C., as Yearbook Separate 1590 (10¢). The historical information on nut varieties is of considerable value.

Illinois Publications (exclusive of many papers on growing nuts in Illinois, to be found in the annual reports of the Northern Nut Growers' Association)

Nut Growing for Pleasure and Profit--E. A. Riehl, Trans. Ill. Hort. Soc. 54, 1920
Chestnuts for Illinois--R. B. Endicott, Trans. Ill. Hort. Soc. 55, 1921
Nut Growing in Illinois--A. S. Colby, Trans. Ill. Hort. Soc. 58, 1924
Possibilities of the Nut Industry in the Middle West--J. A. Neilson, Trans. Ill. Hort. Soc. 63, 1929

1/ No longer available for general distribution but can usually be found in libraries featuring agricultural literature.

Planting Black Walnuts in Illinois--Publication #11, Dept. of Conservation, Division of Forestry, Springfield, Ill., 1938
Some Results of Selection in the Northern Pecan--A. S. Colby, Proc. Amer. Soc. Hort. Sci. 36, 1938
Directory of Markets for Illinois Forest Products--J. E. Davis, Natural History Survey and Univ. of Ill., Mimeo., 1939

## Organization Interested in Securing and Disseminating Information

Membership in the Northern Nut Growers' Association, G. L. Slate, Secretary, Agricultural Experiment Station, Geneva, New York, is open to those interested. Annual meetings are held in different sections of the country, where both newly planted and bearing trees are studied following a program of papers and demonstrations. The annual reports, of which back numbers and an index, published separately, are available, constitute an invaluable working library for the practical nut grower. The American Fruit Grower (monthly), 1370 Ontario Street, Cleveland, Ohio, is the official organ of the association, which sponsors a column of material interesting to nut growers in each issue.

## Partial List of Dealers in Northern Nut Kernels

Bordo Products Company, 541 North Franklin Street, Chicago, Illinois
R. E. Funsten Company, 1517 Morgan Street, St. Louis, Missouri
The James A. Harper Supply Company, 505 West 5th Street, Kansas City, Missouri
Kelling Nut Company, 365 East Illinois Street, Chicago, Illinois
Louisville Coffee Company, 224 West Main Street, Louisville, Kentucky
National Association of Bakers Supply Houses, Henry & Henry, 304 Michigan Avenue, Buffalo, New York
National Confectioners Association, 111 West Washington Street, Chicago, Illinois
National Wholesale Grocers Association, 6 Harrison Street, New York, New York
H. W. Smith Company, 189 West Madison Street, Chicago, Illinois
Joseph A. Stanka, Nut Brokers, 565 West Washington Street, Chicago, Illinois

Caution: Write or interview buyers before sending first shipment. Kernels must be properly cleaned, cured, and packed. Several of these firms will sometimes buy unshelled nuts.

No discrimination is intended in omitting other firms on this partial list. Also, no guarantee of reliability of the dealers listed is made or implied.

Dearborn Street Station in Illinois-Michigan Canal, Chgo. 0
Conservation, Division of Waterway, Springfield, Ill., 1969
Data Bank of Statistics on the Northern Fresh--, St. Louis,
Proc. Amer. Soc. Hydr. Eng. Oct. 25, 1969
Directory of Dredges for Illinois Inland Waterways, S. Ofr.
Planned History Sports on Web. U Ill. Urbana, 1970

## Transportation Inventory in Summary and Its Supplying Information

Inventory is the backbone for planned transportation, R. T. Hale, Summary, Northern Illinois Service, Chgo. New York. In order to close [illegible] and facilities are held in different sections of the country, where with many [illegible] and handling costs are needed to calculate a program of saving on inventory [illegible]. The usual way is, a which book keeping and in later, multiplied accounts are available, mechanical or [illegible] working labour for the problem was [illegible] Marshall Field & Co. (London), 1970 [illegible] Chgo. [illegible] official cases of the accountants. Often quarter a [illegible] of [illegible] [illegible] to [illegible] in each [illegible].

## Partial List of Leaders in Inland Waterways Research

[illegible] Transport Research, Inc. North Lake Shore Drive, Chicago, Illinois.
A. B. Dearborn Company, 1111 Morgan Street, St. Louis, Missouri.
The Fred L. Hedges Supply Company, 90 East 5th Street, Kansas City, Kansas.
Pullman Inc Company, 79 West Illinois Street, Chicago, Illinois.
Lake Valley Coffee Company, 400 Fox Lake Street, Dodgeville, Wisconsin.
Illinois Association of Water Supply Systems, Road & River, 100 Michigan Avenue Building, New York.
Marshall Engineering Consultants, 111 West Washington Street, Chicago, Illinois.
National Industrial Energy Association, 6 Sunshine Street, New York, New York.
E. V. Smith Company, 101 West Madison Street, Chicago, Illinois.
Joseph A. Ahrens, 200 Broadway, 200 West Washington Street, Chicago, Illinois.

Conclusion: Write or inquire a lumber before supplying first shipment. Between week 1 [illegible] channel, rental, and general. Without of course there will accessories and [illegible] order.

In discrepancies in inland a supplying some items or that special line, no guarantee of availability of the material items. In case of doubt.

grafting in order that the stubs will finish bleeding before the scions are set and the excess sap will not be so likely to drown out the scions. It may be advisable at this time to remove some branches which may later interfere with the growth of the scion. Just before grafting, an additional three to six inches should be cut off carefully with a sharp fine-tooth saw to provide a fresh working surface. The sawed surface should then be smoothed with a knife at the places where scions are to be set. A flattened area which often occurs on the trunk makes an excellent place in which to set a scion for the side graft. It may be desirable to choose a place for grafting a few inches above a side branch. The bark on the side of the stub is then slit straight down from one and one-half to two inches, and a small wedge of bark on each side of the initial cut is removed to make the opening at the top from one-fourth to three-eighths inch in width, depending upon the size of the scion to be used. The sides of this cut should be beveled underneath as the wedge is removed.

A spreader stick, preferably of hickory or some other hard wood, should be shaped to correspond to the shape of the scion but a little shorter and narrower. This is inserted between the bark and the wood of the stub where the cuts have been made, to loosen the bark. The spreader should be left in place while the scion is being prepared.

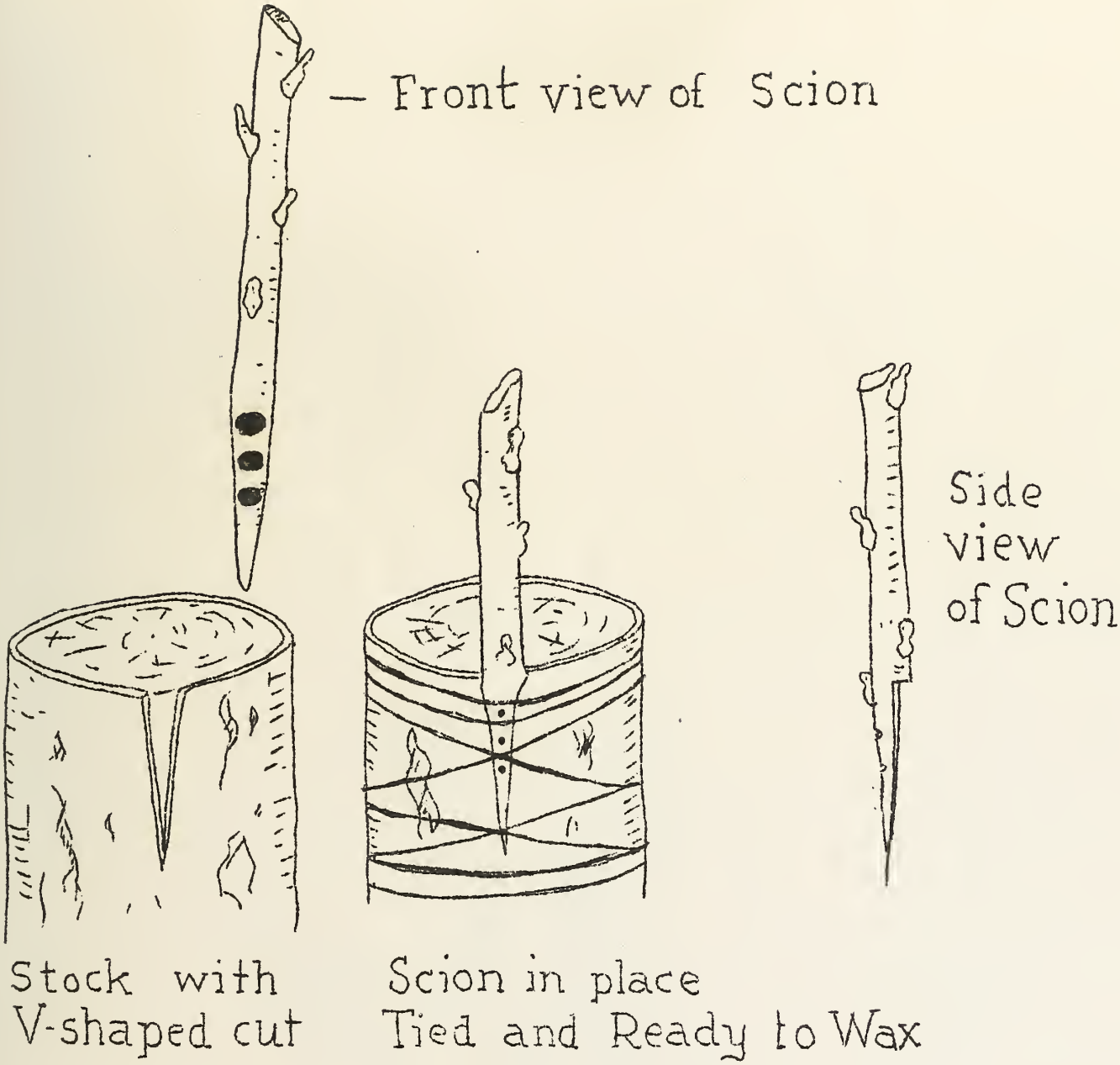
In preparing scions, a section of healthy one-year-old wood from four to six inches in length and approximately five-eighths inch in diameter should be selected. With a sharp knife, the butt end of the scion should be shaped into a tongue one and three-quarters to two and one-quarter inches long by making a sloping cut and exposing the cambium layer. The tongue should be smoothly tapered from shoulder to point, where it should be as thin as possible without feathering. Then about two-thirds of the thickness of the scion should be cut away, extending in beyond the pith on the back of the tongue and leaving the shoulder square at the top in order to insure a firm seat. Some propagators recommend that two or three small notches be cut through the bark in the outside of the tongue so that a small amount of sap can collect there to aid in starting callousing. The scion should be inserted in the stock immediately after it is prepared.

Properly cut scions should carry two buds above the tongue, with the lower bud on the outside and at the top of the tongue. If the scion has a terminal bud, it should be removed, as it is easy to force and may start growth before a complete union has been made between scion and stock.

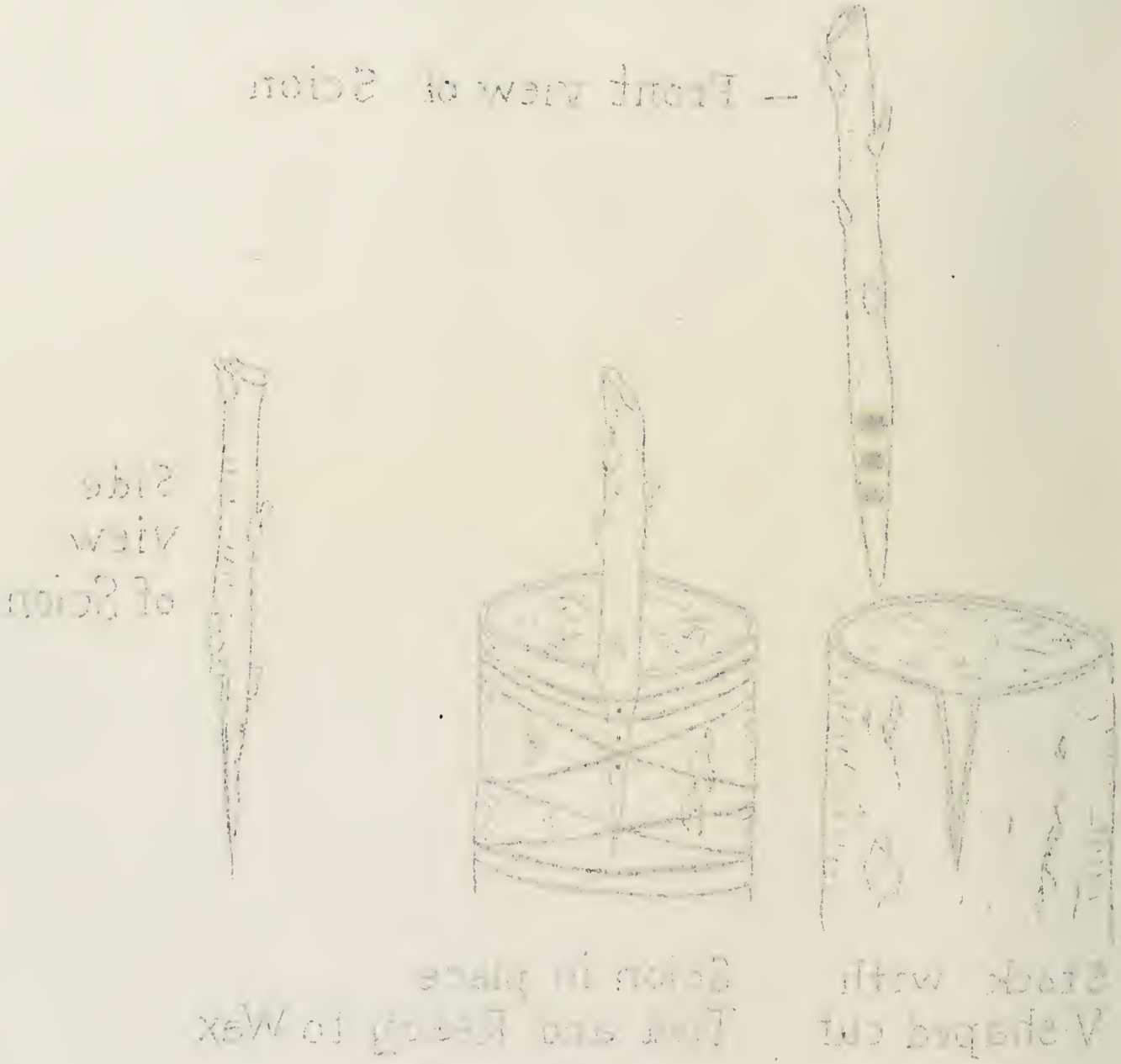
Two scions should be set, one each on opposite sides of the stub, except where stock less than one and one-half inches in diameter is being used, in which case but one scion is placed. The stub and scions are then bound with soft twine tied with one or two half hitches at the bottom, and are entirely coated with grafting wax which is brushed on. Strips of cotton cloth are then laid across the top of the stub in such a manner as to cover it completely and extend down the side for at least an inch. The stub is wrapped about four inches down with a narrow strip of cloth which will adhere to the wax. Some propagators make a short cut with a knife through the bark on each side of the stub (not directly below the scions already set) to prevent flooding the scions with sap. The cuts are made about 8 inches below the graft union. The entire graft is then covered with a paper sack of convenient size, tied to the stub and left for about two weeks. A slit should be made in the sack for ventilation.

Later, the twine should be cut on one side to prevent injury by girdling, but should not be removed. This may be done at the time the sack is removed. Instead of twine, some propagators are using one of the new elastic tapes, which will deteriorate within a few weeks and do not need to be cut.

If the graft makes a vigorous growth, it will be necessary to support it in an upright position for one or two years by fastening a small pole or strip of lumber to the tree and tying the graft to it by some means such as a wire, run through a piece of rubber hose, to prevent chafing. Suckers should be discouraged by cutting back or removal if they tend to dwarf the new growth from the scion. If two scions are used on the stub and both grow, the less desirable one should be removed before the next growing season. With a fine-tooth saw, a slanting cut should be made at the side of the stub to facilitate the removal of the unnecessary graft, and the wound should be covered with wax or similar protective material.




ECEg
8-15-41
H44


Front view of Scion
Side view of Scion
Stock with V shaped cut
Scion in place Tied and Ready to Wax

# GENERAL INFORMATION FOR ILLINOIS NUT GROWERS

Department of Horticulture
College of Agriculture
University of Illinois, Extension
Service in Agriculture and
Home Economics
Urbana

John W. Lloyd

# METHODS FOR REMOVING SPRAY RESIDUE

By
W. A. Ruth and K. J. Kadow, Department of Horticulture
University of Illinois

July 1, 1934

As a result of our experiments last year we are making the following suggestions and recommendations.

Analysis: The washing treatment should be based upon, and varied with, the amount of residue that the apples carry when picked, and upon the difficulty involved in its removal. In cases that are at all doubtful, the only safe procedure requires analytical control.

It is an obvious fact, which nevertheless requires emphasis, that, without adequate analyses, the growers are entirely in the dark. If a washing process is inadequate, the grower should know exactly how far he must go to meet the tolerances; otherwise he cannot hope to modify his washing process intelligently. On the other hand, without analysis, his washing treatment may be unnecessarily severe or costly.

An entirely satisfactory analytical control calls for several steps.

a. An analysis of each variety when the fruit is almost ready to pick. The results of this analysis, and a knowledge of the spray program and the materials used in spraying, can be used to suggest methods and materials for washing a test sample. Heating the washing solution, increasing the concentration of the acid, the use of a wetting agent in the acid bath or as a predip, and slow progress of the fruit through the washer all facilitate removal.

b. A test sample should be washed and analyzed. If the federal tolerances are not met, with a reasonable margin of safety, the method should be changed in accordance with the above paragraph and the re-

sult determined by a further analysis. The tolerances are 0.01 grain arsenic ($As_2O_3$) and 0.019 grain lead per pound of apples.

c. If there is any reason to suspect the necessity of a change in the method of washing as the season advances, another analysis should be made. For example, if no means of heating the solution is provided, the temperature of the washing solution may drop before all of the crop of one variety is washed; if this occurs, it will be necessary to analyze the fruit to be certain that it is still meeting the tolerance.

Apples washed to test the effect of equipment, solutions, and temperatures should be washed in the equipment that is used to wash the crop, and in exactly the same way. To insure the progress of the apples through the machine in the normal way, and at the normal rate, it will be necessary, in most equipment now in use, to wash two or three bushels, which is considerably in excess of the amount required for analysis.

A record should always be made of the washing process which a sample represents. All important data should be set down, including the temperature of the solution, the concentration of each ingredient, and the length of time that the fruit takes to pass through the machine.

The State Department of Agriculture, at Springfield, will have a man in the field to take samples for analysis, according to Mr. H. M. Newell, Superintendent of the Division of Standardization and Markets. The man taking the samples will also find out, through the various farm bureaus, which growers will have fruit that they will want to have analyzed. In case it should be necessary for growers to send in samples by mail or express, they should be sent to the Division of

Foods and Dairies Laboratory, Department of Agriculture, Springfield, Illinois. There should be at least four pounds of apples in each sample. The apples selected should carry the heaviest residue, and should be of average or less than average size for the variety and crop. If the package is sent by parcel post, information in addition to the grower's return address, which should be on the container itself, must be in a stamped envelope attached to the package. The grower should indicate how he wishes to be notified of the results of the analysis, that is, whether he should be notified by wire or by card. The analysis will be completed, according to Mr. Newell, within 24 hours, or less, after the receipt of the sample.

Washing machinery: Washing machines now in use float the apples in the washing solution, or flood or brush them with it, or combine two or all of these processes. The most efficient commercial machines flood the apples with the solution as they pass over a series of brushes.

Flotation machines (paddle washers) can be made by the grower. The cost of the materials should not exceed $150. Specifications are given in Farmers' Bulletin 1687, "Removing Spray Residue From Apples and Pears." The Department of Horticulture of the University now has a limited number of copies of this bulletin for free distribution. Copies can be obtained for five cents from the Superintendent of Documents, Washington, D. C. Commercial machines which depend primarily upon flotation are also on the market.

Our experiments indicate that the appearance of apples washed by flotation may be a serious objection to this process if they have been heavily sprayed with lead, lime, and oil. Apples washed in this way have a dull finish and appear to carry considerable residue although

lead and arsenic may have been reduced to amounts that are well within the tolerance. If the amount of residue to be removed is lighter, or if somewhat different spray materials have been applied, this objection to washing by flotation may not hold. Apples washed in an underbrush flood machine are bright and look as though they had been entirely freed from residue.

Thorough rinsing, with a final rinse in fresh water, applied as a spray or flood, is an absolute necessity in order to avoid injury from the washing solution. Two or three gallons of fresh water are required for rinsing each bushel of fruit. The rinse water left in the blossom ends of the apples should not have an acid taste. The water used in the final rinse should run into the rinse tank. The apparatus to spray the apples as they emerge from the rinse tank can consist of pipes drilled with holes along the bottom.

It is not an absolute necessity to dry the washed fruit before it is packed, but it is very desirable because of the improvement in appearance and the lessened danger of infection with rotting organisms. Commercial driers, to be used with flotation machines, are available, and are a part of the flood type and underbrush flood type machines.

The acid bath: Hydrochloric acid bath has proved better than sodium silicate as a wash for apples sprayed with a combination of lead arsenate, lime, and oil; it will probably be better whenever lime or materials made from lime are contained in the residue. The acid is much better than any of the commercial materials so far tested.

The strength of the acid solution can vary with the amount of residue to be removed and with the difficulty of its removal. It is probably not desirable, even if the load is very light, to use less than 1/2 of one percent actual acid. If the residue is heavy and difficult to remove, 1 1/4 percent actual acid should be used at 110° F.

(See paragraph, Injury). The strength can be increased to 1 3/4 percent at 70° F. without producing injury.

Commercial hydrochloric (muriatic) acid can be bought in three strengths. these are 28% actual acid (18° Baume); 32% actual acid (20° Baume); and 35.4% actual acid (22° Baume). The 32% acid is commonly used. The container should specify the strength, either in percent or in degrees Baume. Occasionally the strength is indicated in specific gravity instead of degrees Baume: 28% equals 1.143 specific gravity; 32% equals 1.163 specific gravity; 35.4% equals 1.180 specific gravity.

The acid can be bought in ten- to twenty-gallon glass carboys in wooden containers. It should not be permitted to come into contact with the skin or clothing; if it does, accidentally, it should be rinsed off as soon as possible, and the spots on the skin and clothes should be neutralized with hydrated lime or baking soda, which should be at hand. Care should be observed not to inhale fumes from the container. An arrangement for tipping the container should be constructed. The acid corrodes metals, so that glass, earthenware, or porcelain measures must be used.

Amounts of acid required to secure various dilutions and to make depleted solutions up to full strength are given in the appended table.

The washing solution should be made up fresh after each full day's run, or the equivalent of a day's run if the machine is run at less than capacity. The solution should be tested at intervals to see that it is up to strength.

The equipment for testing consists of one 10 c.c. bulb pipette (c.c. stands for cubic centimeter), one 10 c.c. measuring pipette, a three-ounce glass bottle, and 1,000 c.c. of testing solution. (This will be a little more than a quart, which is 973 c.c.) One thousand

c.c. of the testing solution should contain 23 grams of sodium bicarbonate (chemically pure baking soda) and enough methyl orange to produce an easily visible yellow color. A pharmacist can make up the solution, and the pipette can be bought at or through a drug store.

To make a test, transfer 10 c.c. of the diluted acid from the wash tank to the bottle with the bulb pipette. The 10 c.c. mark on this pipette is the ring around the part of the stem above the bulb. The solution is drawn above this ring by suction, and allowed to flow back to the mark before it is run into the bottle. The measuring pipette is filled to the 0 c.c. mark with the test solution in the same way. The test solution is allowed to run slowly into the bottle containing the acid until the color of the solution in the bottle changes to yellow and remains yellow after gentle shaking. Moistening the tip of the finger placed against the end of the measuring pipette helps to control the rate of flow of the solution. One should shake the bottle gently while adding the solution. The number of c.c.'s of the test solution divided by 10 equals the strength of the acid. The test should be repeated, to insure accuracy.

The temperature of the washing solution: The temperature of the solution appears to be the most important variable factor in washing. In our experimental work in the fall of 1933, about six times more lead and arsenic remained on fruit washed at 65° F. than on fruit washed at 110° F. At still lower temperatures, which are often encountered in the fall, correspondingly greater amounts would have been left. Methods of heating are described by R. H. Reed in a mimeographed paper, "Heating Systems for Warming the Washing Solution in Apple Washing Machines," which should be available from this Station after the first of July.

Wetting agents: The wetting agent most thoroughly tested is Vatsol. This material increases the effectiveness of the acid solution, especially in flotation washing, where it is added to the acid at the rate of 8 pounds per 100 gallons, making a 1% solution. In machines which agitate the solution, Vatsol produces so much foam that it must be used at a very low concentration if it is used at all. Used at 1/30% (4½ ounces in 100 gallons) in the underbrush flood type machine it facilitates removal to some extent.

Predipping: The function of predipping appears to be to facilitate wetting the fruit with the acid solution when it is passed into the acid bath. The predipping bath should therefore be a solution of a wetting agent. In flotation machines predipping seems to be unnecessary, because the wetting agent can be used at full strength in the acid. If the apples are washed in machines which agitate the solution, it is an advantage, under certain conditions, to predip the fruit in 1% Vatsol. The conditions referred to are those which retard removal, such as the use of inefficient machinery, too rapid washing, the use of temperatures below the highest safe temperature, and wax accumulation on the fruit due to late picking, etc. The home-made washer can be used for predipping. If necessary, acid can be used in addition to the wetting agent, which transforms the predipping machine into an auxiliary washer. In this case, provision should be made for heating the predipping (prewashing) solution if difficulty in removal is anticipated.

Spray schedule: Oil-containing sprays applied near harvest make removal especially difficult. The spray program advocated by this Station allows for this fact.

The exact effect of a spray program cannot be predicted. The experimental work of last year showed, however, that the residue could be removed to a point well within the tolerance from Grimes and Jonathan which received the last spray of lead arsenate (4 pounds per 100 gallons) and lime (8 pounds per 100 gallons), combined with 1% summer oil or 3/4% miscible oil, three weeks before harvest. The total load of lead on this fruit varied from 0.103 to 0.183 grains per pound. The arsenic varied from .039 to .068 grains ($As_2O_3$) per pound. A much heavier load could have been removed, because the residue left after washing was so far below the tolerance. These apples were washed in 1¼% acid containing 1/30% Vatsol in the underbrush flood type machine for 30 seconds at 110°F. Washing by flotation for 2½ minutes in 1¼% acid containing 1% Vatsol, at a temperature of 110° F. would have been equally or more effective; the temperature could have been considerably lower. Kinnairds carrying a much heavier residue (.094 grains of $As_2O_3$ and .292 grains of lead per pound) were washed with equal success. The last spray, of lead, lime, and miscible oil, had been applied six weeks before harvest.

Injury: The most drastic washing treatment used last year resulted in a slight increase in the loss of weight in cold storage in open containers. There was no visible increase in shriveling and the effect was not commercially important. The treatment that produced this effect was flotation at 110° F. for 2½ minutes in 1¼ percent actual acid and 1% Vatsol. The fruit that was washed was fully mature. Green fruit is probably more subject to injury. To be on the safe side, the temperature of this particular solution should not be above 90° F., if the fruit is somewhat green, and if the fruit is exposed to the solution for this length of time. This precaution applies

especially to summer apples. It is not desirable to allow the fruit to become too mature, in order to avoid the possibility of injury in washing or to improve its color, because of the danger of increased difficulty in residue removal due to wax excretion. Apples should be washed immediately after picking because residue removal is much easier then than later.

To prevent apples from remaining in the machine too long, and thereby being injured, most of the machines now in use, including the flotation machines, must be kept constantly supplied with apples, which should be fed into the machine at a uniform rate.

The following table indicates the amount of commercial acid to use in making up 100 gallons of acid wash of various strengths. The table also shows the amount of acid that must be added to a depleted washing solution to bring back its original strength. If, for example, a test shows that the acid is 0.2% low, it will be necessary to add either 6 pints of 28% acid, 5 pints of 32% acid, or 4½ pints of 35.4% acid.

| Acid content required in wash, % | Amount required to make 100 gallons | | | | | |
|---|---|---|---|---|---|---|
| | 28% acid (18°B.) | | 32% acid (20°B.) | | 35.4% acid (22°B.) | |
| | Gallons | Pints | Gallons | Pints | Gallons | Pints |
| 0.1 | -- | 3 | -- | 2½ | -- | 2 |
| 0.2 | -- | 6 | -- | 5 | -- | 4½ |
| 0.3 | 1 | 1 | -- | 7½ | -- | 7 |
| 0.4 | 1 | 4 | 1 | 2 | 1 | 1 |
| 0.5 | 1 | 6½ | 1 | 4½ | 1 | 3½ |
| 0.6 | 2 | 1½ | 1 | 7 | 1 | 5½ |
| 0.7 | 2 | 4 | 2 | 1½ | 2 | -- |
| 0.8 | 2 | 7 | 2 | 4 | 2 | 2 |
| 0.9 | 3 | 2 | 2 | 6 | 2 | 4 |
| 1.0 | 3 | 5 | 3 | 1 | 2 | 6½ |
| 1.25 | 4 | 4 | 3 | 7 | 3 | 4 |
| 1.50 | 5 | 3 | 4 | 5 | 4 | 2 |
| 1.75 | 6 | 2 | 5 | 3½ | 5 | 0 |
| 2.00 | 7 | 1 | 6 | 2 | 5 | 5 |

# SPRAY RESIDUE REMOVAL

By W. A. Ruth and K. J. Kadow
Department of Horticulture, University of Illinois

The work that we are reporting is based upon hundreds of tests and thousands of analyses. We shall attempt to summarize it, putting into words the most important facts. The endless charts that might be shown would only be confusing. At the same time, successful washing calls for just as close study of details as spraying. The details of washing are new, while the details of spraying have accumulated gradually. As might be supposed, it has been found that spraying and washing are closely related; the materials that are put on must be taken off. Changes in the details of spraying introduce new details and new problems in residue removal.

## EXPERIMENTAL DATA

### General

The increase in residue due to one application of spray: Analyses of Jonathans August 20 immediately before and just after spraying show that one application of lead, lime, and oil increases the load of lead by approximately 1/10 of 1 grain per pound of fruit.

The rate of loss of lead from sprayed fruit: In dry weather, sprayed fruit loses very little residue, and, in wet weather, the rate of loss depends upon the constituents of the spray as well as upon the rainfall. Even in rainy weather, the rate of loss is slow enough to base a trial washing process upon analyses made a week before harvest, and to permit the readjustment of the washing process in accordance with the result of the preliminary test, provided analyses are immediately available.

The ratio of lead to arsenic: If the lead tolerance is met, the arsenic tolerance will, almost invariably, be met also, because the arsenic weathers off more rapidly than the lead. The lead to arsenic ratio in lead arsenate, as is applied to the trees, is 2 to 1. The present ratio of the tolerance of lead to arsenic is 1.9 to 1, which is almost the same. The ratio on the fruit immediately after spraying is also 2 to 1, but it may increase to 5 to 1 in 4 or 5 weeks, or less. This year, in southern Illinois, lead usually ran 3.5 or 4 parts to 1 part of arsenic at harvest. In western Illinois, at harvest, it ran 2 or 2.5 to 1. The difference was probably due to drier weather in western Illinois. The lead load therefore cannot be estimated indirectly by multiplying the result of an arsenic analysis by two, but must be found by direct analysis. In this paper it will be necessary to consider only lead residues, although arsenic analyses are available.

The effect of omitting lime in spraying upon the lead residue at harvest: The effect of lime in the spray is to increase the rate of lead loss by weathering. Illinois apples sprayed with lime, lead, and oil carried, at harvest, only a third or a fourth the lead retained by apples sprayed with lead, oil and spreader. For this reason, most western Illinois growers were meeting the tolerance easily by washing with comparatively ineffective solutions; that is, in 0.6 to 0.9 percent acid at 60 to 70 degrees, without a wetting agent. These are not effective temperatures or solutions. The best that can be said is that the solutions and temperatures used could not harm the apples. The growers shipped the washed apples without analyses, and hoped, fervently, that they were meeting the tolerance. They hoped, fervently, but they could not be sure.

# SPRAY RESIDUE REMOVAL

By E. A. Rush and K. C. Kemp
Department of Horticulture, University of Illinois

The work that we are reporting is based upon hundreds of tests and thousands of analyses. We shall attempt to summarize it, putting into terms the most important facts. The audience should right be above would only be confusing. In the one, successful washing only for just as close study of details as spraying. The details of washing are new, while the details of spraying have been studied quite fully. As might be supposed, it has been found that spraying and washing are closely related; the materials that are put on must be taken off. Changes in the details of spraying introduce new details and new problems in residue removal.

## EXPERIMENTAL DATA

### Spraying

The increase in residue due to one application of spray: Analyses of Jonathan August 20 immediately before and just after spraying show that one application of lead, lime, and oil increased the load of lead by approximately 1/10 of 1 grain per pound of fruit.

The rate of loss of lead from sprayed fruit: In dry weather, sprayed fruit loses very little residue, if any at most seasons. The rate of loss depends upon the conditions of the spray, oil on the material. When in rainy weather, the rate of loss is slow enough to have a trial washing process upon analyses made a week before harvest, and to permit the washing of the washing process in accordance with the results of the preliminary tests, provided analyses are immediately available.

The ratio of lead to arsenic: If the lead tolerance is met, the arsenic tolerance will, in most instances, be met also, because the arsenic weathers off more rapidly than the lead. The lead to arsenic ratio in lead arsenate, as is applied to the trees, is 1 to 1. The permanent ratio of the tolerance of lead to arsenic is 1.3 to 1, yet at present the same. The ratio on the fruit immediately after spraying is about 4 to 1. As it may increase to 2 to 1 in 4 or 5 weeks, or less. This year, in southern Illinois, lead usually was 3.5 or [illegible] to 1 part of arsenic at harvest. In central Illinois, at harvest, it ranged 2 [illegible] to 1. The differences are probably due to minor variations in weather in Illinois. The lead load therefore cannot be estimated indirectly by multiplying the arsenic analysis by ten, but must be found directly analyzed. In this case it will be necessary to consider only lead residue, although arsenic analyses are available.

The effect of omitting lime in spraying upon the lead residue at harvest: The effect of lime on the speed [illegible] the rate of lead loss by weathering. Illinois apples sprayed with lime, lead, and oil carried, at harvest, only a third or a fourth the lead retained by apples sprayed with lead, oil and spreader. For this reason, most eastern Illinois growers omit lime in the tolerance easily by washing when comparatively ineffective solutions show it, in 0.4 to 0.9 percent acid at 60 to 70 degrees, without a washing [illegible]. [illegible] effective temperature or solutions. The best that can [illegible] solutions and temperatures used could not have the effect. The [illegible] washed apples without analyses, and hoped, forcefully, that the [illegible] tolerance. They hoped, forcefully, that they could not be [illegible].

Dry brushing: Several Illinois growers this year were giving their apples a preliminary dry brushing before washing. Because of the improvement in appearance it was thought that the brushes might be having considerable effect. Analyses in our laboratory proved conclusively, however, that the dry brushes were having no effect whatever. A much better plan would have been to precede washing with an eliminator in order to remove the small apples that clog the washers. Dry brushes can be used, if desired, to polish the fruit after the tolerance has been met by washing.

The effect of lime in the spray upon residue removal: Apples sprayed with lime, in addition to lead and oil, are much more successfully washed in acid than apples sprayed with lead and oil without lime, even when they carry as heavy a load of lead.

If apples have been sprayed with lime, acid is a much better single wash than silicate. All Illinois commercial apples sprayed with lime, lead, and oil, in 1934, could be washed successfully in acid. Acid is about five times as effective as silicate on lime-sprayed apples.

## Acid Washing

Some of the tests run last year in acid washing were repeated, and new tests were run.

The effects of temperature, time, and wetting agents were again tried, both in flotation washing and in brush washing.

Temperature in flotation washing: Raising the temperature from 70 to 110 degrees decreased the residue by one-half. Although the effect of heat was much greater ~~than~~ last year, it again proved to be important.

Time in flotation washing: At 110 degrees the maximum effect in flotation was produced in 1 minute. At 70 degrees, $1\frac{1}{2}$ minutes was better than 1 minute; 2 minutes was still better.

Vatsol concentration in flotation: One-eighth percent Vatsol was found to be as effective as 1 percent. It reduced the residue left by 50 percent. It was equally important at 70 and at 110 degrees.

If a flotation washer is used, therefore, and the load of lead is heavy, the temperature can be raised, or Vatsol can be used, or both, depending upon the load and the difficulty of removal.

Temperature in brush washing: Raising the temperature had almost exactly the same effect in the underbrush washer as it had in flotation.

Vatsol in brush washing: Vatsol was effective at 70 and 90 degrees, but not at 110 degrees. If an underbrush washer is used, therefore, the maximum effect can be obtained by raising the temperature of the solution to 110 degrees; at lower temperatures, at least up to 90 degrees, Vatsol can be used to advantage, but without producing the maximum effect of which the machine is capable.

Vatsol at various concentrations in brush washing: A concentration of 1/30 percent Vatsol, which was all that could be used in the brush washer without excessive foaming, was as good as 1 percent Vatsol with #16 defoamer; if there was any difference, the lower concentration was the better.

[illegible]

## Silicate Washing

There are two reasons for interesting ourselves in washing with sodium silicate.

1. In the far west it has been found superior to acid in cleaning waxy or oily fruit. Illinois fruit, because of our change in spray materials, is carrying much more oil than formerly. We should certainly experiment with silicate washing.

2. Its possibility for tandem washing, followed or preceded by acid.

Sodium silicate is an alkali, and is the most successful alkaline wash so far tried. There are several kinds of sodium silicate, varying in alkalinity. The kind used for apple washing contains 19.4 percent alkali (as sodium oxide). Eighty pounds per 100 gallons, the customary amount, was used in these experiments. Soap was added, at the recommendation of the manufacturers. Vatsol, however, may prove to be a better wetting agent than soap.

Temperature: Sodium silicate was found to be increasingly effective in the brush washer up to 125 degrees. The use of high temperatures for a 30-second treatment in a brush machine will often be practicable. Sodium silicate is less injurious than acid, which could scarcely be used at 125 degrees.

Time: In flotation washing at 110 degrees, $1\frac{1}{2}$ minutes was better than 1 minute.

Brushing: Thirty seconds in the underbrush machine was more than twice as effective as 30 seconds in the flotation machine.

The effect of brushing for 30 seconds in the underbrush washer could be approximated or equalled by flotation for $1\frac{1}{2}$ minutes.

The place of silicate in single washing: Sodium silicate is as effective as acid at 110 degrees on fruit sprayed with lead and oil without lime, but it is not more effective. On fruit sprayed with lead, lime, and oil, it proved to be only one-fifth as effective as acid.

## Tandem Washing

Because the fruit is washed twice, once in alkali and once in acid, tandem washing can be expected to be more effective than either acid washing or alkali washing alone. Surprisingly in our experiments, it proved to be at least four times as effective as a single wash of acid or silicate. The first process took off three-fourths of the original load, and the second process took off three-fourths of what was left.

Order of tandem washing: One of the important questions is whether the acid or the silicate should come first. It was found that the silicate should precede the acid, regardless of how the fruit had been sprayed, that is, whether or not lime had been used. The two washes were about one-third more effective in that order than they were when the acid came first.

The most effective tandem processes: In our experiments in tandem washing we used two lots of fruit that were very difficult to wash. One was from the Fennville, Michigan, Cooperative. The apples had accumulated wax in the packing shed for a period of three weeks, and did not respond satisfactorily to the washing process that the Fennville Cooperative was using. This lot of fruit was presumably the hardest to wash

in Michigan. We were asked to try washing it in our equipment. The other lot, from southern Illinois, carried almost twice as much lead, but the apples had not been exposed to a high temperature after picking. The surface, therefore, had not accumulated excessive wax.

It was found possible to get the lead on the Michigan sample under the tolerance by any of three tandem processes, which were as follows:

1. Washing for $\frac{1}{2}$ minute at 110 degrees in the Bean brush machine in silicate, containing soap, followed by flotation for 1 minute at 110 degrees in $1\frac{1}{4}$ percent acid containing Vatsol. (Our test)

2. Washing for $\frac{1}{2}$ minute at 110 degrees on the Bean supplementary flotation brush, followed by flotation for $1\frac{1}{2}$ minutes at 110 degrees in $1\frac{1}{4}$ percent acid containing Vatsol. (Test at Fennville, our analysis)

3. Flotation for $1\frac{1}{2}$ minutes at 110 degrees in silicate containing Vatsol, followed by $\frac{1}{2}$ minute in $1\frac{1}{4}$ percent acid at 110 degrees, without Vatsol, in the Cutler machine. (Fennville test, our analysis)

The lead on the Michigan apples was reduced 93 to 94 percent by each process. It fell just under the tolerance.

The most effective tandem process tried so far on the Illinois apples removed 95 percent of the lead, which was not quite enough to meet the tolerance. This process consisted of flotation for $1\frac{1}{2}$ minutes at 110 degrees in silicate containing soap, followed by flotation for $\frac{1}{2}$ minute at 110 degrees in $1\frac{1}{4}$ percent acid containing Vatsol. A slightly longer treatment in the acid, or brushing in the acid, would probably have reduced the lead to a point below the tolerance. This is one of the experiments still to be run.

We can conclude that, in tandem washing, any one of several procedures can be used in the silicate bath, followed by any one of several processes in the acid bath. The same factors govern the efficiency of each bath that govern their efficiency when used alone; i.e., temperature, time, wetting agents, brushing, and agitation. Silicate should come first.

## Washing Injury

Acid injury: Injury sustained in acid washing is sometimes very important, and it should determine the washing process at all times. Injury varies with the variety and the season. Grimes, Jonathan, and Willow Twig, were easily injured this year. Last year they were not. Ben Davis, Winesap, York Imperial, Delicious, and Stayman, were resistant both last year and this year. The difference in the resistance of Grimes, Jonathan, and Willow Twig this year and last year appears to have been due partly to cracking, caused by rains following prolonged drought, and partly to a slight russeting, which may possibly be attributable to the same weather conditions. Acid injury was more severe on immature fruit than on more mature fruit. It consists in cracking, usually concentrically around the calyx. In extreme cases it occurs on the sides also; it then causes serious withering.

The condition of the surface of sensitive varieties can be used to predict the probability of injury from washing. With sensitive varieties, at least, a preliminary test should always be run. Although the injury develops gradually over a period of weeks, a day's observation, if the apples are kept at a temperature of 70 to 80 degrees, will reveal the probability of serious injury, if it is to occur.

Injury increases with an increase in the temperature of the acid bath, with the duration of immersion, and with the concentration of the acid. It is also increased by Vatsol. Little or no acid injury followed washing at 70 degrees, even this year, but, in our experiments, washing at 110 degrees for $2\frac{1}{2}$ minutes injured sensitive varieties severely. It is fortunate that most western Illinois Grimes, Jonathans, and Willow Twigs could be washed this year in acid at low temperatures and concentrations.

Silicate injury: Injury from sodium silicate is usually due to incomplete rinsing. Sodium silicate is comparatively hard to rinse off, and the rinse should be especially thorough. This type of injury is confined to the calyx and, where it produces a solid round burned area, somewhat like arsenical injury, but different in the regularity of its outline. Silicate at high temperatures can also induce cracking, which resembles acid cracking in its appearance and distribution.

## CONCLUSIONS

The most important conclusions are, very briefly, as follows:

1. The washing process should be based on the spraying treatment, upon analyses of the fruit for lead, both before and after washing, and often upon preliminary tests for injury.

2. Judging from this year's experiments, apples sprayed with lime, lead, and oil can be washed successfully with acid. Sodium silicate should not be substituted.

3. Also judging from this year's results, tandem washing will often be required if lime is not used.

4. Preliminary dry brushing has no value.

5. It is especially necessary to guard against heavy residue on the varieties most sensitive to acid.

Injury increases with an increase in the temperature of the acid solution, with the agitation of the solution, and with the concentration of the acid. It is also increased by Vitaal. Little or no acid attack followed working at 70 degrees, even this year, but, in our experiments, working at 110 degrees has 24 minutes injurious corrosive results severely. It is fortunate that most vessels Illinois Steel, Joliet, and Milton Tube could be washed this year in acid at low temperatures and concentrations.

Pickling Injury: Injury from pickling difficulty is usually due to inclusions metals. Wrong pickling is conservatively hard to place off, and the place should be carefully observed. This type of injury is confined to the edge and, there it produces a solid round metal area, somewhat like crystalline injury, but different in the regularity of its outline. Similar to high temperatures and also induce cracking, which resembles cold cracking in its appearance and distribution.

CONCLUSIONS

The most important conclusions are, very briefly, as follows:

1. The cooling process should be based on the pouring temperature, upon analyses of the fluid for lead, both before and after cooling, and often upon cooling temp for injury.

2. Pouring from this year's experiments, engine grouped with lime, lead, and all can be washed successfully with acid. Sulfur additions should not be substituted.

3. Also pouring from this year's results, vacuum cooling will often be required if lime is not used.

4. Preliminary dry brushing has no value.

5. It is especially necessary to guard against heavy reliance on the variability and sensitive to acid.